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MEDICAL RESEARCH COMMITTEE

STATISTICAL REPORTS

No. 1.—656 CASES OF GUNSHOT WOUND OF THE HEAD



June 13, 1918

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In close relation to the work the Medical Research Committee have undertaken for the Army Council in the compilation of the formal Medical Statistics of the War, the Committee have provided accessory help in various directions for the collection and preservation of medical records and of the after-histories of military patients, with a view both to the present guidance of medical officers and to the future purposes of the Medical History of the War. This accessory statistical work has been effected by the arrangements made for the interchange of information between separate medical units overseas and between those overseas and at home, by the schedule system of collecting information in chosen series of cases, by clerical help supplied for tracing personal histories after discharge, and in other ways. Many communications giving statistical summaries of the results of treatment in various classes of medical and surgical patients have already been published by permission in medical journals, and others have been given in several of the reports issued or published by the Committee. With the sanction of the Director-General, A.M.S., the Committee have made arrangements to issue from time to time for official distribution statistical summaries which, whether from their provisional nature or for other reasons, are not proposed for publication elsewhere.

The present statistical note on a series of 656 cases of gunshot wound of the head has been compiled by Captains Adie and Wagstaffe, R.A.M.C., with the aid of the schedule system organized by the Committee, and it is hoped that this may be the first of a series which will have immediate interest for the guidance of present work and future value as preliminary material towards the compilation of the Medical History of the War.

For purposes of reference it may be noted here that the following statistical summaries of other groups of cases of gunshot wound of the head have already been published:—

Gordon Holmes and Percy Sargent. 'Injuries of the Superior Longitudinal Sinus.' *British Medical Journal*, 1915, 2, 493.

J. E. H. Roberts. 'The Treatment of Gunshot Wounds of the Head, with special reference to apparently minor injuries.' *British Medical Journal*, 1915, 2, 498.

G. G. Tabuteau. 'The Treatment of Gunshot Wounds of the Head, based on a series of ninety-five cases.' *British Medical Journal*, 1915, 2, 501.

H. M. W. Gray. 'Observations on Gunshot Wounds of the Head.' *British Medical Journal*, 1916, 1, 261.

Percy Sargent and Gordon Holmes. 'Report on the Later Results of Gunshot Wounds of the Head.' *R.A.M.C. Journal*, 1916, 27, 300.

Harvey Cushing. 'Notes on Penetrating Wounds of the Brain.' *British Medical Journal*, February, 1918, 221.

Harvey Cushing. 'Study of a Series of Wounds involving the Brain and its Enveloping Structures.' *British Journal of Surgery*, 1918, 5, 558.

A NOTE ON A SERIES OF 656 CASES OF
 GUNSHOT WOUND OF THE HEAD
 WITH A STATISTICAL CONSIDERATION OF THE
 RESULTS OBTAINED

BY CAPTAIN W. J. ADIE, R.A.M.C., S.R.
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1. INTRODUCTION.

In the Spring of 1916 arrangements were made for the cases of gunshot wound of the head which occurred in the Army Area to be evacuated to this Hospital for operation, if they were fit for transport. That arrangement has persisted, and we are now able to present the results of 656 cases which have passed through our hands during the 20 months which have elapsed since the scheme was initiated. Included in that total are a fairly large number of cases on which an operation had been performed previous to admission here, and it has been intensely interesting to compare the results in the two series of cases.

The cases which are sent here for operation are selected at the C.C.S. as being able to stand the journey; in judging this the pulse has been practically the sole criterion. Any case with a pulse-rate below 100—no matter what the severity of the wound—will stand the journey.

The cases are accordingly of a varying degree of severity—from the small punctured wound type to the large gash with brain matter exuding freely; the largest wound of this type that we have had measured eight (8) inches in length.

Those cases which have been operated on before admission also vary enormously in severity, and are, so far as one can judge, of approximately the same average degree of severity as those admitted here before operation.

The cases which are transferred here for operation are sent by motor ambulance direct from the C.C.S.—a journey taking on the average 2-3 hours. Those cases which have been already operated on are, as a rule, transferred here by barge.

In this series has been included every case of Gunshot wound of the head that has been admitted to this Hospital, alive or dead, up to the 31st of December, 1917.

We want to lay particular stress on the results that we have obtained, not because we regard them as particularly good, but rather because no extensive series of cases of gunshot wound of the head in which full notes have been kept, and in which subsequent examinations have been made in all cases of death has, so far as we can find, been published in any language. Without some such series it is impossible to tell what results are being obtained, or how treatment is improving the results.

2. NUMBERS OF CASES.

TABLE I.

CASES OF GUNSHOT WOUND OF THE HEAD ADMITTED TO NO. —
GENERAL HOSPITAL. MAY, 1916, TO DEC. 31ST, 1917.

		Total	Deaths	Mortality
Class A. Involving penetration of dura	Not operated on before admission	236	117	49%. Operative mortality 44%
	Operated on before admission (average period between date of wound and admission = 9·2 days)	114	28	25 %
Total for Class A	.	350	145	41 %
Class B. Fracture of skull. Dura not penetrated	Not operated on before admission	117	13	
	Operated on before admission	55	3	
Total for Class B	.	172	16	9 %
Class C. Scalp wounds	.	118	1	
Class D. Fracture of base or concussion. No scalp wound	.	16	2	
Total	.	656	164	25 %

In Table I are shown the numbers of cases that have been treated here analysed according to the type of wound. In Table IA these are still further subdivided showing the difference between the period May–December, 1916, and January–December, 1917. It is interesting to note the comparative uniformity in each class which indicates that no appreciable improvement has been introduced into the treatment.

TABLE I A.

CASES OF GUNSHOT WOUND OF THE HEAD ADMITTED TO NO.—
GENERAL HOSPITAL.

Cases admitted : during period May, 1916, to December, 1916. (Roman type.)
 " " January 1917, to December, 1917. (Italics.)

		Total	Deaths	Mortality
Class A. Involving penetration of dura	Not operated on before admission	100 136	47 69	47 %. Operative mortality = 43 % 50 %. Operative mortality = 44 %
	Operated on before admission	51 63	15 13	30 % 20 %
	Average period between date of wound and admission 7·6 days for cases admitted in 1916			Average period between date of wound and admission 10·6 days for cases admitted in 1917
Total for Class A	.	151 199	62 82	41 % 41 %
Class B. Fracture of skull. Dura not penetrated	Not operated on before admission	42 75	3 10	
	Operated on before admission	17 38	1 2	
Total for Class B	.	59 113	4 12	7 % 10 %
Class C. Scalp Wounds	.	55 63	1	
Class D. Fracture of base or concussion only. No scalp wound	.	3 13	2	
Total	.	268 388	66 97	24 % 25 %

3. PROCEDURE AND SURGICAL TECHNIQUE.

It will be best if we first consider the procedure adopted in this hospital with regard to the treatment of these cases.

Cases transferred from the C.C.S. for operation on arrival here are, if their general condition permits, X-rayed on admission, and before passing to the wards. It is found that this can be done in the majority of cases, even of the most severe type of injury, and it is very occasionally that the restlessness of the patient makes the task impossible. In these cases we do not persevere in the attempt, and no other steps, such as anaesthetization, are taken to render the X-ray possible, as it has been found that the effect on the patient who is to undergo a severe operation in the course of a few hours is—as one would on general principles suppose—extremely deleterious.

The patient is then transferred to the ward, where he is placed in bed, warmed up, and made as comfortable as possible, and any restlessness that may be shown is, if necessary, combated with morphia. The dressing is changed and the site of the wound cleaned as well as possible.

After a period ranging from 4 to 24 hours the patient is brought to the theatre, having received an hypodermic injection of—

Morph. Hydrochlor.	$\frac{1}{4}$ gr.
Atrop. Sulph.	$1/120$ gr.
Hyoscine Hydrobromide	$1/100$ gr.

three-quarters of an hour before his arrival at the theatre. This preliminary injection we regard as invaluable both for the reason that it renders the patient comparatively somnolent and tranquil on coming to the theatre, and keeps him quiet for some hours subsequent to the operation, diminishing greatly post-anæsthetic vomiting and excitement. The patient is anaesthetized with chloroform and ether, the head is shaved and cleansed, and the operation performed.

It has throughout been our custom in this hospital to perform the operation under these conditions, and we consider that a general anaesthetic preceded by morphia and scopolamine injection the best form of anaesthesia for these patients. Recently it has become more and more the custom to laud local anaesthesia in these cases. Here, too, a preliminary injection of morphia and scopolamine is usually given. Certainly without this previous narcotization local anaesthesia is doomed to failure, but even with it we consider that general anaesthesia has the greater advantage for the following reasons.

1. The majority of the patients while not unconscious are at least in possession of an imperfect control of themselves, and are liable to make sudden purposeless movements, which are fatal to the success of the operation. They will also resent the covering of the face and similar inconveniences to which the patient must necessarily be put in these cases.

2. The factor of time is an important one where a large number of cases have to be dealt with. It is common experience that to

obtain a perfect state of anaesthesia over a considerable area by means of a local anaesthetic takes anything from ten minutes to a quarter of an hour longer than it does by means of a general anaesthetic.

3. Freedom for the surgeon in the extent of his operating field is essential, and is difficult and frequently tedious to ensure to an adequate extent when an anaesthetization is local.

An advantage of the local anaesthesia method, of course, is that no skilled anaesthetist is required. This is, however, frequently owing to restlessness or other peculiarity of the patient, a fallacious assumption, whereas if warmed ether is given by the Shipway apparatus the difficulties of the anaesthetist are minimal, and any intelligent V.A.D. can rapidly learn to anaesthetize even the most seriously wounded cases. After all there are few cerebral surgeons of note who operate as a routine under local anaesthesia in civil cases.

As regards the operation itself as performed here there is little to be said. We have, on the whole, followed the recommendations of Colonels Sargent and Holmes. That is to say, in all penetrating wounds of the dura, when the wound of the scalp has been small, we have excised the wound down to the bone. Then, taking fresh instruments, we have turned down a flap large enough to leave a considerable margin around all the injured bone. The hole in the bone is then enlarged so as to leave at least $\frac{1}{4}$ inch of healthy dura all round the perforation. Bony and other fragments that are shown by the X-ray are then removed from the brain if they are easily accessible. The finger is usually inserted into the brain to a depth of 1- $\frac{1}{2}$ inches in an attempt to find any fragments which may be palpable, and which if felt are removed. The whole operation is done under a stream of warm saline. All accessible fragments having been removed the flap is replaced. The excised wound is sewn up with a rubber-tube drain inserted down to the perforation in the dura, and the flap sutured with rubber-tube drains at the angles. Dressings are applied, and the whole head firmly bandaged.

Latterly Major Harvey Cushing has recommended the use of a Carrel syringe and soft wide catheter to remove brain and débris, and to obviate the necessity for the insertion of the finger into the brain. Personal experience shows this method to need a considerable amount of practice, but we hope to become more adept in its use.

When the scalp wound is large this method of turning down a flap to include the wound is not of course applicable in many cases. The obvious expedients have been resorted to. No attempt is made to reach deeply seated foreign bodies.

Rapidity in operation has been a point that we have set much store by. The time taken in the average complete operation as described from the first incision to the time the patient is ready to leave the theatre has been thirty minutes. We found that it was necessary to be quick over the operation because the shock experienced by the patients was considerable, and it was very noticeable how the patients improved when the flap was replaced.

More extensive experience, however, has led us to the opinion that really a more deliberate and thorough cleansing of the wound—more particularly of the wound of the brain with the removal of all possible accessible fragments—is indicated, and that greater deliberation in reflecting the flap, and care in avoiding as far as possible loss of blood in so doing, are important points, and that it is on these lines that improvement in technique will proceed.

On completion of the operation the patient is then taken back to the head ward where all the necessary measures are taken to combat shock. The subsequent treatment of the case proceeds on general principles on the line of the maintenance of the patient in the condition of the most perfect quiet possible. To obtain this we do not hesitate to give repeated doses of morphia, which we regard as the most valuable drug in the treatment of these cases. We have seen no cases in which any disadvantage followed the frequent and prolonged use of it in this type of case.

Here, too, we may emphasize the paramount importance of skilled and highly specialized nursing. In fact we may say that the success or failure of the treatment is largely in the hands of the nursing staff. If the staff can so look after the patient that he does nothing for himself, that he lies absolutely quiet and unmoving, then his chances are very much better than with less skilful nursing. Of all the surgical patients that one sees in military hospitals, head cases are, as a whole, the hardest and most exacting to nurse, and require the most vigilant supervision, a fact appreciated by few who pass through the ward and see all quiet and apparently tractable.

As regards the duration of stay of patients in hospital here it has been our rule to keep all cases in which the dura is penetrated until they are able to get up. In cases which show an uninterrupted recovery this is usually five to six weeks. Then it is considered that they can without risk of further injury be evacuated to England as cot cases. Cases not involving penetration of the dura are evacuated to England about a fortnight after the subsidence of all their symptoms.

4. GUNSHOT WOUNDS OF THE HEAD WITH PENETRATION OF THE DURA.

TABLE II.

GUNSHOT WOUNDS OF THE HEAD WITH PENETRATION OF THE DURA.

Recoveries.

	Not operated on before admission to No.—Gen. Hosp.	Operated on at C.C.S.
Total number of recoveries	119	86
Total number of cases showing complications	16	38
Fits	6	5
Continued headache and pyrexia	8	20
Attacks of headache and vomiting	1	2
Persistent mental aberration	1	7
Persistent restlessness		4
Percentage of complications	13 %	44 %
Average length of time under observation	41 days	37·6 days

TABLE III. CASES OF GUNSHOT WOUNDS OF THE HEAD WITH PENETRATION OF THE DURA ADMITTED TO NO. — GENERAL HOSPITAL WITHOUT PREVIOUS OPERATION.

Analysis of Cause of Death.

TABLE IV.

CASES OF GUNSHOT WOUNDS OF THE HEAD WITH PENETRATION OF DURA OPERATED ON AT
C.C.S. AND SUBSEQUENTLY TRANSFERRED TO NO. — GENERAL HOSPITAL.

Analysis of Cause of Death.

CAUSE OF DEATH:	DAY OF DEATH (days after being wounded)	?												TOTALS								
		6	7	9	10	11	12	14	15	16	17	19	20		21	22	30	34	42	51		
1. Lateral ventricle involvement. No sepsis and purulent basal																						
2. " meningitis																						
3. Cerebellar laceration																						
4. Meningitis																						
5. Purulent basal meningitis																						
6. Cerebral abscess. Encephalitis																						
7. Secondary haemorrhage fr. middle meningeal artery																						
8. Bronchopneumonia																						
9. Septicaemia (multiple wounds)																						
10. Cause unknown. (No post-mortem performed)																						
11. Suicide																						
Totals per day		1	1	2	2	1	1	2	1	1	1	1	2	1	1	1	3	1	2	2	1	
Totals per period		6													11			5	1	2	2	28

Our results in this most important class of case are shown in the Tables II, III, and IV. They have been arranged so as to compare the results obtained by operation here and those obtained by operation at the Casualty Clearing Stations and subsequent evacuation here.

(a) *Recoveries.*

First as regards recoveries. Here the interesting point is to compare the number of cases showing complications that are found in each series. As might be expected in view of the widely held opinion that head cases stand transport very badly after operation, the percentage of complications is very much higher in cases that have been operated on up the line and transferred here subsequent to operation. The forms of complication that are most marked are (1) persistent headache and pyrexia; (2) persistent mental aberration. This latter variety is almost unknown in our experience for cases that have not been moved after operation. The difference is sufficiently striking to give strong support to the argument for retaining the patients for a prolonged period in hospital before evacuation. As will be seen later, this difference still persists in later hospital treatment in England.

(b) *Deaths.*

As regard the deaths. The mortality in the two classes of course differs greatly and it is difficult to compare them in any way. Some sort of a comparison may be made as follows. It will be seen that the average time elapsing between date of wound and admission here in C.C.S. operated cases is 9.2 days. If the percentage mortality is taken for those cases operated on here and dying after the ninth day, it is found to be 24 per cent., which closely corresponds with the mortality in cases operated on at the C.C.S. and transferred here subsequently. There is, therefore, probably but little difference in the mortality, and the effect of transport, while producing complications as mentioned above, is seldom sufficiently severe to be fatal.

5. GUNSHOT WOUNDS OF THE HEAD INVOLVING FRACTURE OF THE SKULL BUT NOT PENETRATION OF THE DURA. (Tables V and VI.)

TABLE V.

GUNSHOT WOUNDS OF THE HEAD INVOLVING FRACTURE OF THE SKULL BUT NOT PENETRATION OF THE DURA.

Recoveries.

	Not operated on before admission	Operated on at C.C.S.
Trephined	35	36
Complications : total number	4	7
Fits	4	
Persistent headache and pyrexia		3
Attacks of headache and vomiting		1
Persistent mental aberration		3
Severe fractures. Not trephined	37	2
Complications : total number	2	1
Fits	1	
Persistent headache and pyrexia		1
Cerebral abscess	1	
Slight fractures of undetectable. Not trephined	33	14
Complications : total number	1	7
Fits	1	1
Persistent headache and pyrexia		2
Attacks of headache and vomiting		1
Persistent mental aberration		3
Total number of cases	105	52
Total number of complications	7	15
Percentage of complications	6 %	28 %

TABLE VI.

GUNSHOT WOUNDS OF THE HEAD INVOLVING FRACTURE OF THE SKULL BUT NOT PENETRATION OF THE DURA.

Deaths.

A. Not operated on before admission.

(Note :—The T indicates that the patient has been trephined.)

Days wounded	1	2	3	4	5	6	7	8	9	10	11	Totals
Cerebral laceration	T 1											1
,, ,, pressure			T 1			T 1						2
,, ,, extradural haemorrhage	(T 1)	2										2
,, ,, lateral ventricle involved	1											1
,, ,, longitudinal sinus involved	1											1
,, ,, pneumonia						T 1						1
Cerebellar laceration		1										1
Cerebral congestion and pneumonia			1									1
Gaseous encephalitis	T 1											1
Meningitis	T 1										T 1	2
Cerebral softening												
Totals	7	1	2			2				1		13

B. Operated on before admission.

Days wounded	3	16	37
Purulent basal meningitis	T 1		
Cerebral abscess			1
Bronchopneumonia. ? B. I. P. P. poisoning		T 1	

(a) *Recoveries.*

Here again the percentage of cases showing complications is far higher in the cases which have had to stand transport after an operation. As before, the most common complications are headache and pyrexia and mental aberration.

(b) *Deaths.*

These mainly occur in the first ten days. It has been interesting to note that in certain cases it is possible for infection to reach the meninges through the bruised intact dura. It is probable that in a certain proportion of these cases the dura has been injured by a spicule of bone. We have, however, seen one case in which on trephining there was found to be a fracture of the outer table only. The dura was considerably bruised. The wound, a large lacerated one, became very septic and the suppuration extended through the bruised dura causing death from meningitis.

Here is raised the extremely interesting question whether it is advisable to trephine all cases in which there is fracture of the outer table of the skull. It is admittedly impossible to tell from the appearance of the outer table what is the condition of the inner table. We have seen one case in which the inner table was fractured under an intact outer table, and we have seen many cases of very extensive fracture of the inner table with a very small injury to the outer table. The two cases of cerebral abscess in this class were both cases of the latter type. A further difficulty arises in that in many of the cases the X-ray photograph fails to indicate any definite fracture.

On the other hand, the operation of trephining is not free from risk, as is shown by the fatal case quoted above. Complications (fits) have in our series been more frequent in the trephined than in those that have not been trephined.

It has been our practice here to leave a large proportion of depressed fractures untouched, as is seen from Table V. More extended experience, however, makes us more and more inclined to trephine in, at any rate, all cases of serious fracture. This is not by any means for the purpose of view of relieving any symptoms that may be present except of course in the case of pressure; but solely in order to cleanse the wound as completely as possible, and to avoid such disastrous complications as cerebral abscess.

Another point that comes up for consideration here is the question of the diagnosis and treatment of increased cerebral pressure in recent cases. In these cases the classical signs of cerebral pressure are, in our experience, not present. The cardinal signs may be said to be unconsciousness usually deepening, rapidity of pulse, and rise of temperature. As regards the treatment it is indeed difficult to say what is best. Our practice has been to do what is indicated in the way of a cleaning operation, and to attempt to alleviate the pressure in the early stages by lumbar puncture, but not to incise the dura. Incision of the dura we believe to be fundamentally incorrect and merely to expose the patient to a grave risk of intracranial infection.

6. SCALP WOUNDS. (Table VII.)

TABLE VII.

GUNSHOT WOUNDS OF THE HEAD. SCALP WOUNDS; NO FRACTURE.

Total	Total showing complications	Deaths
118	3 Fits	1. 2nd day pneumonia

The treatment here adopted has been throughout the same. Excision and suture. Union has been per primam in just over 70 per cent. of the cases.

7. CASES SHOWING SEVERE CONCUSSIONAL CHANGES WITH OR WITHOUT FRACTURE OF THE BASE; NO SCALP WOUND.

In this class we find cases essentially similar to the fractured base of civil practice. The treatment is the same.

TABLE VIII.

CASES SHOWING FRACTURE OF THE BASE AND SEVERE CONCUSSION.

Total	16	
Recovered	14	
Complications	2	
Fits		
Died	2	

1 case on third day : cause of death—cerebral congestion and pneumonia.

1 case on first day : cause of death—cerebral laceration.

8. COMPLICATIONS CONSIDERED IN GREATER DETAIL.

(a) Fits.

In the cases which recovered fits occurred in 23 (5 per cent.). The *time of onset* was always within the first seven days after the patient had been moved from the C.C.S. after operation, or after operation at the hospital here, and most occurred on the day after admission (in cases already operated on at the C.C.S.), or on the day after operation (in cases sent direct to us). The time of onset depended on this movement or operation, and bore no definite relationship to the time that had elapsed since the time the man was wounded.

Nature. The fits varied from slight twitching of a part to generalized convulsions with loss of consciousness. In most cases (15) the fits, beginning on the side opposite to the wound, became general and consciousness was lost. Of the remainder, in six, the fits were localized to one part or to one side, and the patient did not lose consciousness. One man with a non-penetrating occipital wound had visual fits—without loss of consciousness, and another wounded in the right temporal region—non-penetrating—had gustatory fits, during which he had, as he said, ‘a nasty taste like antiseptics’ in his mouth and a ‘queer feeling’ in his head.

Number of fits. The attacks varied greatly in number from a single fit in 10 cases up to 20 or 30; but in no case did a fit recur once the bout was over, although the cases were under observation for three weeks or more. A definite relationship exists between the nature of the wound and the occurrence of the fits, for they were commonest in cases of scalp wound, in which at the operation no injury to the skull was apparent, or in which an intact or very slightly damaged dura was found under a depression. Of the remainder in which the dura was penetrated, the majority occurred in cases which had been operated on at the front, and very few, in cases operated on at this hospital and kept quiet, although the great majority of penetrating head wounds observed were operated on here.

In fatal cases fits were not so common. Generalized convulsions were rare, and the commonest type of seizure was a twitching, most often of the face alone, sometimes more widespread, which continued off and on for hours, sometimes for days. This was, as a rule, evidence of cortical meningitis spreading up from the base along the Sylvian fissure over the motor area, and was merely an incident in the last days of a patient already dying of basal meningitis.

Contrast these fits in fatal cases with those first described. In those in patients who ultimately recover the fits occur during the first week after movement or operation; they begin in a part corresponding to the position of the wound; generalized convulsions are common; they are of considerable violence and of short duration; they are perhaps the only alarming clinical sign and their significance is slight. In the fatal cases the attacks may begin any time after admission; they begin in parts not necessarily related to the site of the wound; continuous twitchings are the commonest form, and the patient is already seriously ill. If meningitis has not yet been diagnosed, their significance is great when added to the other symptoms; if it has, they only make an already bad prognosis worse.

Briefly, then, fits occurred in five per cent. of the recoveries. They occurred during the first week after admission; they were never spread out over a period longer than three days; they never recurred, and they were most common in cases where no operation was done on the skull, or where the dura was intact or the brain only slightly damaged.

It will be noted that in these cases there was an exact correla-

tion between the site of the wound and the nature and point of origin of the fits. An occipital wound caused visual fits, a temporal wound caused gustatory fits, and wounds over the motor areas caused convulsions.

This distinguishes these early cases sharply from those in which epilepsy develops late as the result of a head wound—traumatic epilepsy in which, it is said, no such correlation exists.

Are these men who have had fits early, and who perhaps have had no operation performed on the skull, more likely to develop traumatic epilepsy than any other cases of head wounds? Nothing that we have learnt from the replies that we have received from home of the after results of these cases leads us to believe that they are.

Does the occurrence then of fits alone justify an operation on an intact skull? We think the answer is No.

(b) *Meningitis.*

In those cases which survived the shock of the wound and operation, meningitis was the cause or partial cause of death in the majority of our fatal cases.

In every case except four the dura was penetrated; in two there was no fracture of the skull and the path of spread of the infection was not discovered; in two the infection spread through an apparently intact dura.

Symptoms may appear at any time after admission as our patients arrive at various times after being wounded.

In cases operated on at the base and kept there the patient often appears to do well until the seventh or tenth day after operation. We only begin to feel happy about cases, so far as meningitis is concerned, when fourteen days have passed, without any untoward signs. The earliest sign to be noted may be that, with or without any rise of temperature, the patient becomes 'much brighter'. He is talkative, and amuses those around him with his quaint criticisms and remarks on his surroundings. Or more commonly he becomes querulous and is considered by inexperienced nurses to be merely 'naughty'. Within twenty-four hours, however, he begins to complain more insistently, the temperature rises, the neck becomes stiff, the ominous cry, 'Oh, my head' is heard; he becomes very restless, especially at night, and the typical meningitis is developed. All the fatal cases died within the first six weeks, the great majority before the end of the third week.

Post-mortem. Basal meningitis and a rupture into the lateral ventricle were found in sixteen cases, basal meningitis alone in four, cortical meningitis alone in two, a combination of cortical and basal meningitis in seven, and this combination with rupture into the ventricle in five; so that all the fatal cases had basal meningitis except two, and in all except thirteen the lateral ventricle had been opened.

All the cases are not fatal, however, as we have seen several men with all the signs of meningitis and with an infected c.s.f. make a complete recovery. To illustrate the fact that no case is

hopeless we mention the case of Pte. S. This man developed a definite meningitis. He was delirious—temperature 104°; he had nystagmus and severe hiccough, and his case looked quite hopeless. He also had a large hernia. One day when being dressed he suddenly put up his hand and removed his hernia. He made a good recovery. When saying good-bye on the day he went to England, he said he was feeling ‘fine and dandy’, and he wanted to know if he was a bad enough case ‘to make Canada’. He is the only case of meningitis that we have seen develop hiccough and recover.

Treatment. Lumbar puncture was done in many cases and we think it should be done in all, and repeated as long as a free flow of fluid is obtained. Unfortunately after two or three punctures only a few drops of fluid are obtained in most cases, showing that the foramen of Majendie is blocked and that it is useless to persist.

More elaborate methods of treatment such as washing out the ventricles and spinal canal have not been tried.

(c) *Cerebral Abscess.*

Fourteen cases of cerebral abscess were observed—twelve with penetrating wounds, two with non-penetrating wounds. The cases fell into two definite clinical groups. First those typical of cerebral abscess alone (nine cases), and second, those in which the symptoms of abscess were complicated by infection of the membranes.

The cases in the first group ran a similar course, and it is possible to give a general description which will apply to all with the exception of three cases which will be mentioned later.

In all these six cases the dura was penetrated and the brain severely damaged. The usual operation was done on admission. The wounds did not heal by first intention, but suppurated for a varying time and then either healed (three) or continued to discharge a small amount of pus (three).

The temperature, irregular for a few days at first, settled. The patient was quiet and seemed to be doing well. This quietness, pleasing at first, soon aroused suspicion. When spoken to the patient answered sensibly, and made no complaint except perhaps of slight headache. But left to himself, he showed little interest in his surroundings, he never started a conversation himself, he wrote no letters, he never read the papers. He began to get thin and seemed to have lost his inclination for food. The temperature became subnormal with an occasional rise to 100°-101° which settled again in one or two days. The chart also showed a gradual slowing of the pulse week by week. This was not evident on merely glancing at the chart, but came out clearly on close analysis. Sooner or later, generally about the sixth week, an occasional pulse reading in the low fifties appeared. The patient then began to vomit and the stage of fully developed abscess was reached.

The patient is now very quiet—he lacks volition—he vomits occasionally, but may complain little. He is pale and thin. A tense hernia has formed under the healed scalp wound, or a hernia, present from the first, has increased in size. Any neurological signs, which were present at first, have increased in severity, or

new signs have appeared. Optic neuritis is present in most cases (four out of six). The pulse is slow and the temperature is mainly subnormal.

The patient remains in this condition perhaps for several weeks, and then comes the end which is as sudden as the onset was gradual.

He suddenly becomes worse, the temperature shoots up, the pulse-rate is greatly increased, and death takes place within forty-eight hours, from rupture into the lateral ventricle. Or, soon after operation, the temperature rises, and the patient dies from meningitis or a spreading encephalitis.

The average date of death was the seventieth day after being wounded. The earliest death was on the thirty-fifth day. One lived 122 days.

Post-mortem. In all these cases well localized abscesses were found deep in the brain at a distance from the track of the wound, and often in silent areas. There was one abscess in two cases only, in three cases there were two, and in one there were five. Two abscesses contained fragments of indrawn bone, in the remainder no foreign body was found.

The lateral ventricle was opened in four cases, in one by rupture of the abscess itself, in three by the extension of a softening process from the track of the wound. In two the ventricle was intact.

One case showed well-marked old basal meningitis; in two the membranes were uninfected; in three there was recent cortical or basal meningitis.

An operation was done and an abscess found and drained in all but two of these cases without materially affecting the result.

This sketchy account is intended to give an idea of the course in the majority of the cases suffering from cerebral abscess alone. In two cases we were more fortunate. In one the abscess was drained and healed, but the patient died from other causes (he had a fractured femur); in another the patient made a complete recovery.

This patient, Pte. W., was admitted to this hospital on Nov. 14th, 1917, with a scalp wound in the right parietal region, over the lower part of the motor area. His general condition, except for some bronchitis, was very good. He had no paralysis. He was operated on next day when the scalp wound was excised and the skull examined. No fracture was detected and the wound was sutured. The wound healed by first intention except at one point in its centre which discharged a small quantity of pus. The temperature was irregular for the first ten days, but as he had bronchitis and did not complain of his head little importance was attached to this. After the tenth day the temperature was normal, generally subnormal, and all went well until the twenty-second day when he vomited several times. This was attributed by the nursing staff to tinned rabbit. He was very quiet when left alone but bright when roused; he complained when questioned of headache. He was not taking his food well, was rather pale, and looked a little thinner. His pulse was slowing down and a reading in the fifties had appeared for the first time that day. His tem-

perature was nearly always below 98.4°, but had risen twice to 99° in the preceding ten days.

On going over him we thought that the left abdominal reflexes tired more easily than the right, and that the veins of the fundus were slightly engorged, and that the inner edges of the disks were slightly hazy. Next day he said he was much better, but he did not look it. His pulse was 50, his temperature 98°, and a slight weakness in the movements of the left side of the face was detected. Next day he vomited again, once only, his headache was worse, his pulse fell below 50 at times, and a definite but very slight loss of power in the grasp of the left hand which had not been there before was found.

The diagnosis was now made, and looking back we felt that it should have been made sooner. But was there enough to go on? He only had a scalp wound we thought. It is common enough to see a slow pulse in convalescent head cases—many patients in bed run a subnormal temperature, and it is just these cases of scalp wound which have the most persistent headaches.

True he vomited several times in one day, but one swallow does not make a summer, especially at Christmas time! No, it was the weakness in the face and arm that made the diagnosis certain.

We make this case the justification for a plea that all head cases should be examined neurologically on admission, and that a note should be made of what is found. A very simple examination will suffice, but it must be accurate. In the case of Pte. W. just described, if we had not been absolutely certain that there was not the slightest trace of any weakness on the left side on admission—as well there might have been considering of the situation of his wound—several valuable days might have been wasted before we could have been certain that his signs were due to some new process.

As soon as the diagnosis was made he was operated on: a small crack was found in the bone which had not been seen at the first operation, and did not show on the X-ray plate—bone was removed—and the abscess in the brain was drained. The patient made a perfect and uninterrupted recovery.

Second Type. In the remaining five cases the signs and symptoms of abscess and meningitis were so united that it is not possible to give a single description which would be typical of all.

The temperature was irregular throughout, and the pulse did not show the slowing seen in the first group. The patients were restless and noisy, a large hernia developed early, and the whole course of the illness was more rapid.

The average date of death was the forty-fifth day. A single abscess was found post-mortem in all these cases, not shut off, but surrounded by a wide area of softened brain. In three cases the abscess had formed in a hernia, in the other two it had formed in the track of the wound. Bone fragments were found in the abscess in three cases. The lateral ventricle was opened in four cases—in all five the ventricle contained thick greenish pus. Meningitis was present in all. In these cases the abscess was merely a part of a widespread infection of the brain and its membranes.

Summary.

14 cases :— 12 fatal from brain sepsis ;
 1 from other causes ;
 1 recovery.

2 types :— 1. Abscess uncomplicated, 9.
 2. " and general infection, 5.

Prognosis :— Very bad.

Abscess commonly multiple ; 2 or more in 6 out of 9 uncomplicated cases.

Result of Treatment :—

One abscess is found and drained, but operation is often followed by a flare up, and hastens death.

We hope that we have learnt something from the above cases, which will enable us to operate earlier and improve on these bad results.

(d) *Cerebral Hernia.*

The increased intracranial pressure, of which cerebral hernia is a sign, may be set up and maintained by infection, or it may arise with or without infection, and the hernia once formed may be kept up mechanically.

The hernia may be merely a sign of an abscess in the brain, or an abscess may form within the hernia itself whatever its original cause.

In every fatal case of meningitis a hernia formed where this was physically possible. In those cases where no hernia was noted, either the dura was intact or the entrance wound into the cranium was through some part which prevented an operation to enlarge the bony opening, or there was a free escape of cerebrospinal fluid which kept down the intracranial pressure, or finally the infection caused death within a few days before hernia had time to develop.

In cases of meningitis which recovered a hernia was always present, and the hernia receded as the infection was overcome. In many cases with signs of increased intracranial pressure which recovered, where infection was suspected but not proved, a hernia was present, and it receded as the cerebral symptoms abated.

But when all these cases were excluded, there remained a few cases in which a hernia, whatever its original cause, persisted for weeks after all signs of infection had disappeared. In these cases the cause of the persistence of the swelling is apparently a mechanical one, and seems to be due to insufficient bone removal at the original operation.

Hernias are seen most often in cases operated on at the front, and moved to the base soon after operation, but a few occurred, in a much smaller proportion, in cases operated on at the base, and kept there for several weeks.

As a rule the hernia slowly receded with rest in bed alone, and of the few cases sent to England with an unhealed wound, only three had a hernia larger than, say a golf ball, and these were gradually becoming smaller.

Treatment. 1. Rest in bed with patient sitting up for a few hours daily, and the application of a bandage exerting slight pressure, were found to be sufficient in all cases.

2. Operations to increase the size of the bony opening were never performed, as we were aware of the danger of secondary operations in head cases.

3. Lumbar puncture as a routine treatment in cases of uncomplicated hernia was not thought to be necessary.

Summary. Apart from infection, insufficient decompression and early transport after operation are conducive to the formation of a hernia. In every case, if the infection has been overcome, the hernia gradually recedes under the simple treatment mentioned above.

9. FURTHER PROGRESS OF THE PATIENTS AS REPORTED FROM HOSPITALS IN ENGLAND. (Table IX.)

Arrangements have been made by the Medical Research Committee to furnish further particulars of those cases which are sent to England with Buff Postcards (M.R.C. 3). All the head cases leaving the hospital have had this card, and we have received reports on 287 of the cases. These reports are analysed in Table IX. They are furnished for the most part when the patient leaves hospital in England, and so do not give at all a late report on his progress. In fact, as will be seen, the average length of time that elapses between the date of wound and the furnishing of the report is only four months. These figures, therefore, do not give us any suggestion as to the ultimate prognosis in these cases, but there are one or two points of interest upon which it may be worth while to remark.

First, as regards the mortality. Six cases have died; three of them of cerebral abscess; in the case of the other three no post-mortems have been made, but in two of them the history is suggestive of cerebral abscess. In the other death was returned as being due to cellulitis of the head and neck.

Secondly, as regard the complications that have shown themselves. Ninety-six (35 per cent. of the reported recoveries) show some form of complication of which persistent headache is the commonest, occurring unaccompanied by any other complication in 26 per cent. of the reported recoveries. It is noteworthy that in only three cases have fits as yet manifested themselves. In one of the cases the fits are noted as having occurred shortly after arrival in England, and were not repeated—apparently they were brought on by the journey (eighty-one days after the date of wound) and seem to have been of the same type as those we see here after operation or transport. In the other two sufficient information is not furnished. Another point of interest is that the complications in the cases which were transferred to this hospital after operation are proportionately much more numerous than in those cases which were not moved after operation. The actual figures are 47 per cent. of recoveries in cases transferred here after operation, 33 per cent. in cases not moved after operation.

Table IX, Section B shows the number of cases in which there is found a persistent impairment of some function of the nervous system. They have been classified into (*a*) slight, and (*b*) severe. As slight are reckoned pareses of arm and leg or visual symptoms not involving serious loss of vision. As severe are reckoned hemiplegias and hemianaesthesia involving extensive loss of function and conditions such as the spastic type of paraplegia that frequently persists after injury to the superior longitudinal sinus. In all cases improvement appears to have been progressive.

The ultimate results, so far as yet known, are shown in Table IX, Section C. This may be more briefly summarized.

REPLIES FROM HOSPITALS IN ENGLAND. RESULTS SUMMARIZED.

Discharged from army	141
Returned to army work	81
Died	6
Disposal uncertain	59
	287

TABLE IX.

REPLIES FROM HOSPITALS IN ENGLAND.

	GSW.	Head.	Dura penetrated	GSW.	Head.	Fracture of skull.		Fracture of base and conus	Totals
	Not operated on before admission to No.—Gen. Hosp.	Operated on at C.C.S.		Not operated on before admission to No.—Gen. Hosp.	Operated on at C.C.S.		Scalp wounds		
Total number of replies	78	52		71	23		58	5	287
A. Complications :—									
Cases showing no complications	51	27		45	10		39	4	170
Cases showing complications :—									
a. Headache	19	14		19	7		12	1	72
b. Headache and vomiting	1	1		...	...		...	...	2
c. Headache and giddiness	3	...		1	...		2	...	6
d. Headache and mental de- rangements	...	...		1	3		...	...	4
e. Giddiness	1	...		1	...		1	...	3

<i>a.</i> Tinnitus	...	...	1	...	...	1
<i>g.</i> Amnesia	...	...	1	...	...	1
<i>h.</i> Irritability	...	1	...	...	...	1
<i>i.</i> Mental derangement	1	2	...	1	...	4
<i>j.</i> Mental derangement and fits	...	1	...	...	...	1
<i>k.</i> Fits	...	2	...	...	...	2
<i>l.</i> Insomnia	...	...	1	...	...	1
Total number of cases showing complications:—	25 = 33%	21 = 44%	23 = 34%	12 = 54%	16 = 30%	98 = 35%
Cases with insufficient information as to complications	1	1	3	1	1	7
B. Persistent paralysis and/or sensory loss:—						
<i>a.</i> Slight	10	10	3	1	5	30
<i>b.</i> Severe	8	2	2	...	...	13
Total number of cases showing persistent paralysis, &c.	18	12	5	1	5	43 = 15%

C. Results as regards disposal (as noted on schedule)	GSW. Head. Dura penetrated		GSW. Head. Fracture of skull.		Fracture of base and concussion		Totals
	Not operated on before admission to No.—Gen. Hosp.	Operated on at C.C.S.	Not operated on before admission to No.—Gen. Hosp.	Operated on at C.C.S.	Scalp wounds		
1. Permanently unfit	36	21	16	7	1	1	82
2. Unfit	11	11	7	4	1	...	34
3. Invalid	7	5	7	3	1	...	23
4. Invalid A	1	1	...	...	...	...	2
Total discharged from Army	55	38	30	14	3	1	146
5. A 3	...	...	...	...	...	1	1
6. Fit	1	...	9	...	17	1	28
7. Fit C 3	...	...	...	2	3	...	5
8. Home Service	...	...	...	1	...	1	1
9. Furlough and Employment	...	...	1	...	...	...	1
10. , , , ,	11	...	4	...	4	...	8
11. , , , ,	III	7	1	9	1	...	29
12. D 1	...	...	1	1	...	...	2
13. Con. Camp	...	2	1	...	...	...	3
14. Light duty	...	...	...	...	2	1	3
Total discharged to Army work	8	3	25	4	3	81	38

15. Died	1	3	...	...	2	...	0
		(cerebral abscess 176th day)	(cerebral abscess 86th day; cere- bral abscess 207th day; ? cerebral ab- scess 63rd day)		(? cerebral abscess 63rd day; cel- litis of head and face 74th day)		
16. Temporarily unfit	...	...	2	...	2	...	4
17. Sick leave officers	2	...	...	...	...	...	2
18 ? Fit	...	...	...	1	1	...	2
19. Transferred to another hos- pital	5	3	11	2	11	1	33
20. Still under treatment	4	3	1	1	...	...	9
21. Not noted or unknown	3	2	2	1	1	...	9
Total : disposal uncertain	14	8	16	5	15	1	59
Total number of replies	78	52	71	23	58	5	287
Average length of time between date of wound and date of report	4·7 m. (7-12 ¹ ₂ mths.)	4·0 m. (1 ¹ ₂ -9 mths.)	4·3 m. (3 ¹ ₂ -12 mths.)	4·2 m. (1-10 mths.)	3·7 m. (1-18 ¹ ₂ mths.)	3·4 m. (1-6 mths.)	4·2 m.

10. GENERAL CONSIDERATION OF CERTAIN PROBLEMS IN THE TREATMENT OF GUNSHOT WOUNDS OF THE HEAD.

(a) *Where and when to operate.*

There is no need to labour any further the advantage of the centralization of the treatment of this type of case, for the principle is by now pretty generally conceded, but there is a small point of considerable interest that arises, and that is the effect of transport on head cases before and after operation. In order to investigate this point we asked the surgeons at the C.C.S.'s to furnish us with exact particulars of the patient's condition on leaving them, and this was done in forty-one cases. These forty-one cases were for the most part extremely severe penetrating wounds, but it is to be noted that only in two cases did the particular condition become worse on the journey (two to three hours by motor ambulance). Of these two cases, one who had a severe laceration of the cerebellum died suddenly en route—a sudden death is only too frequently the termination in gunshot wounds of the cerebellum. The other case left the C.C.S. with a pulse-rate of sixty-four, unconscious, and very restless. On admission here his pulse-rate had gone up to 160, and he was dead within a few hours with a very acute gas infection of the brain. It is difficult here to blame the transportation for the change in the man's condition. In the other cases there was no change in the patient's general condition (temperature and pulse-rate), or, in those cases in which it was taken, in his blood-pressure. We may take it then that such a journey does not harm the great majority of the patients. On the other hand patients who have been operated on show much more frequently a change for the worse.

Now, when the patient arrives in hospital, how soon should he be operated on? The later the patient can be left the more extensive an operation can be performed. We varied our practice on this point from time to time, and the following table shows the results which have been obtained.

TABLE X.

COMPARISON OF THE NUMBER OF DEATHS FROM SEPTIC INFECTION AFTER GUNSHOT WOUND OF THE HEAD PENETRATING THE DURA IN TWO SERIES OF CASES.

Series A. Cases treated by operation 4 to 12 hours after admission.

Series B. Cases treated by operation 24 to 36 hours after admission.

Day of Death	1-4	5-10	11-20	21-30	31-40	41-50	over 50	Total
Series A.	4 = 3 %	3 = 2.5 %	4 = 3 %	4 = 3 %	6 = 5 %	1 = 1 %	4 = 3 %	26 = 21 %
Series B.	5 = 5 %	10 = 13 %	2 = 2.5 %	4 = 5 %	1 = 1 %	1 = 1 %	3 = 4 %	25 = 33 %

The great increase in deaths in the series B in the period five to ten days indicates the increased incidence of acute infection. It seems to us therefore that it is conclusively proved that the best time to operate is as soon after arrival as possible—an average of some four hours is probably the best. Steps must be taken to guard as effectively as possible against producing shock at the operation, that is to say, that manipulation must be as delicate as possible, and as little blood as possible must be lost.

(b) Improvements in technique or treatment.

The more one sees of this type of work the more one is struck by one's comparative impotence to cope successfully with any severe complication, and every effort must be made to make the primary operation perfectly successful. So far as one can see all improvements must tend in only one direction, that is, towards the more complete cleansing of the wound.

It is in the attention to small details that we are going to improve our results. The Carrel syringe and catheter as suggested by Major Harvey Cushing to supersede the finger may possibly prove one such small detail. Another is the careful avoidance of any unnecessary loss of blood and the consequent possibility of doing a rather more elaborate and deliberate operation. It is our intention to do a series of cases on these lines, carefully checking our results with those we have already obtained. In this way alone can one tell if any advance is being made in treatment.

11. CONCLUSIONS.

1. *General.* The results in the case of patients wounded in the head who are transferred to a special centre where they can be operated on and kept till convalescence are, so far as we can judge, better than the results in the case of those who are operated on at the front and subsequently transferred to the base.

2. *Indications for operation and extent of operation.* All cases with any injury to the scalp require operation. This should in all cases be preceded by X-ray examination. The type of operation preferred for penetrating head wounds has been described in the case of compound depressed fractures without penetration of the dura, the depression should in all cases be removed and a complete cleansing operation performed. In no case should the dura be incised. All scalp wounds should be excised and the skull must be very carefully examined for fracture. The risk of serious complications in scalp wounds is by no means negligible. This point is far too frequently overlooked in these apparently trivial cases.

3. *Technique.* In operating a general anaesthesia is preferable in all seriously wounded cases. Efficient cleansing of the wound is to be arrived at. The best access to the wound of the skull in cases with small wounds of the scalp is given by the reflexion of a flap. Drainage should be provided by means of a small tube both through the excised wound and also at the lateral angles of the flap.

A preliminary injection of morphia, atropine, and hyoscine is essential.

4. *After treatment.* Absolute quiet is essential. Hence the value of a special ward. Large and repeated doses of morphia are indicated if the patients are restless. Patients should be kept in bed in favourable cases for at least five weeks.

5. *Complications.* Fits are common in the early stages. It remains to be seen whether they have any serious significance, as no cases of epilepsy have been reported though patients have been under observation as long as 18 months.

Cerebral abscess is the most common cause of death after the thirtieth day. The chance of the formation of an abscess is far greater if the wound is completely sealed than if a small drainage tube ($\frac{1}{4}$ inch diameter) is left in the excised wound extending down to the hole in the dura.

6. Mortality is approximately 50 per cent. for cases with penetration of the dura which are sent here for operation. These are for the most part cases which arrive at the C.C.S.'s with a pulse-rate less than 100.

Of these deaths rather over three-quarters occur within the first ten days. In fifty-four out of eighty-one cases so dying no septic changes were apparent. In the vast majority of cases dying after ten days the cause of death is some form of intracranial sepsis.

In conclusion we must express our very deep sense of gratitude to Lt.-Colonel Waring, D.S.O., R.A.M.C., for his enthusiastic co-operation and support throughout, and for permission to publish these cases; also to Major-General Cuthbert Wallace, C.B., C.M.G., A.M.S., who has helped us through all our difficulties

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